
INSTRUCTIONS

MODEL 912 Gaussmeter



RFL Industries, Inc.
A Dowty Group Company



Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_07916

INSTRUCTIONS

MODEL 912 Gaussmeter

WARNING:

The Gaussmeter is not to be used in the presence of high voltage.

Do not use the Gaussmeter in the presence of high voltage.

Do not use the Gaussmeter in the presence of high voltage.

Warranty

The Model 912 Gaussmeter is warranted for 12 months from date of delivery for replacement of any part which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f.o.b. Boonton, N. J.

RFL Industries, Inc.
A Dowty Group Company
Boonton, New Jersey, U.S.A.

CAUTION

FOR YOUR SAFETY

THE INSTALLATION, OPERATION AND
MAINTENANCE OF THIS EQUIPMENT
SHOULD BE PERFORMED BY
QUALIFIED PERSONS ONLY.



WARNING:

The Equipment Herein Described Contains High Voltage

Exercise due care during operation and servicing.
Read safety summary on reverse of this page.

SAFETY SUMMARY

The following safety precautions must be observed at all times during operation, service, and repair of this product. Failure to comply with these precautions, or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. RFL assumes no liability for failure to comply with these requirements.

GROUND THE EQUIPMENT

To minimize shock hazard, chassis, cabinets, and equipment racks must be connected to an electrical ground. AC powered products should be equipped with a three-conductor power cable, or equivalent connection on a terminal block. Power cables must either be plugged into an approved three-contact electrical outlet or used with a three-contact or two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of power cables provided meet International Electrotechnical Commission (IEC) safety standards. Equipment provided with terminal blocks, operating from either ac or dc, is provided with appropriate means for connecting an electrical safety ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the product in the presence of flammable gases or fumes. Operation of any electrical equipment in such an environment constitutes a definite safety hazard.

DO NOT OPERATE IN WET OR DAMP AREAS

Do not operate the product in wet or damp areas. Operation of any electrical equipment in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove covers. Replacement of components and internal adjustments must be made by qualified maintenance persons. Disconnect power cable when replacing components. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries always disconnect power and discharge circuits by grounding before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person capable of rendering first aid and resuscitation is present.

DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform an unauthorized modification to the equipment. The product may be returned to RFL for service and repair to ensure that safety features are maintained.

DANGEROUS-PROCEDURE WARNINGS

Throughout this manual, warnings identify potentially dangerous procedures. Instructions contained therein must be followed.

CONTENTS

I	Description	1
II	Specifications	5
III	Theory of Measurement	7
	Gaussmeter	7
	The Hall Effect	8
IV	Operating Instructions	11
	Installation Procedure	12
	General Operation	13
V	Probes	15
	Flat or Transverse-Field Probes	15
	Axial Probe	15
	Tangential Flat Probe	15
	Differential Flat Probes	18
	Differential Axial Probes	18
	High Field Probes (X10)	18
VI	Calibration and Maintenance	19
	Calibration	19
	Equipment Required	19
	Calibration Procedure	21
	Maintenance and Repair	24
	Troubleshooting Checks	24
VII	Circuit Details	29
	State-Variable Oscillator (SVO)	29
	Hall Probe	29
	Range Circuitry and Gain Stage	29
	Gain Stages	30
	Sync Detector, Lowpass Filter	30
	Peak Detector, A/D Converter	30
	Display Driver	30
	Serial-to-Parallel BCD Option	31
	Power Supply	31
VIII	Replacement Parts List	33



Frontispiece: Model 912 Gaussmeter

Chapter I

DESCRIPTION

The Model 912 Gaussmeter is a compact, portable instrument used for measuring permanent magnet DC, and AC fields from 10 milligauss to 100K Gauss using Hall-effect probes. Nominal accuracy is within ± 0.5 percent. Flux density (B) in Gauss, is indicated on a 4½-digit, seven-segment, LED display. Under adverse conditions where magnetic field instability may be excessive, a rear-panel, slide switch may be used to reduce the resolution to 3½ digits.

Built-in calibration circuitry is provided, allowing the user to calibrate the Model 912 at any time at his convenience. This circuit is factory calibrated against reference magnets whose value is known to within 0.2 percent (traceable to the National Bureau of Standards). Instrument calibration may be accomplished by simply placing the range selector to CAL position and adjusting the front panel CAL control for an appropriate reading on the digital display.

In order to select the desired operating mode, i.e., Permanent Magnet - DC, AC or Peak (PK), three pushbutton-type switches are provided. In the PK mode, the peak reading of any static (PM or DC) field is stored in a capacitor for future readout. This offers the user an opportunity to readout data at any later time (within 10 seconds).

NOTE: In this mode, the peak reading of a static field can only be read accurately within 10 seconds, at which time the reading will decay. The memory hold feature is not intended for long-term data storage.

Any one of the instrument's five ranges (10, 100, 1K, 10K, and 100K Gauss) may be selected by means of the rotary range selector. Both, COARSE and FINE, ZERO balance controls are provided to achieve instrument null. However, the instrument cannot be nulled unless a probe is connected to the PROBE socket on the front panel.

The usefulness of the Model 912 can be extended by the addition of a Model 913 Differential Adaptor unit and two matched Hall probes to provide differential magnetic measurement capability; see Figure 1. In this type of an arrangement, magnetic gradients may be analyzed with an ease not attainable by any other technique. Axial, transverse, and tangential fields may be easily measured using any one of a wide variety of Hall probes; details may be found in Chapter V of this manual.

they can also be mounted in a rack configuration as an option; see Figure 2. Also available as options are — BCD and IEEE-488 Bus interface capabilities.

The BCD option provides for binary-coded-decimal output signals to a 25-pin, rear-panel connector. The IEEE-488 bus option provides output and control signals in the format specified for the IEEE-488 bus. This implements TALK and limited LISTENER functions, and enables remote reading and resetting of the instrument.

Two Instruction Manuals are available which describe, in detail, the aforementioned options available with the Model 912:

- (1) Instruction Manual — Model 913 Differential Adaptor for use with Model 912 Gaussmeter.
- (2) Instruction Manual — BCD and IEEE Options for the Model 912 Gaussmeter and Model 916 Fluxmeter.

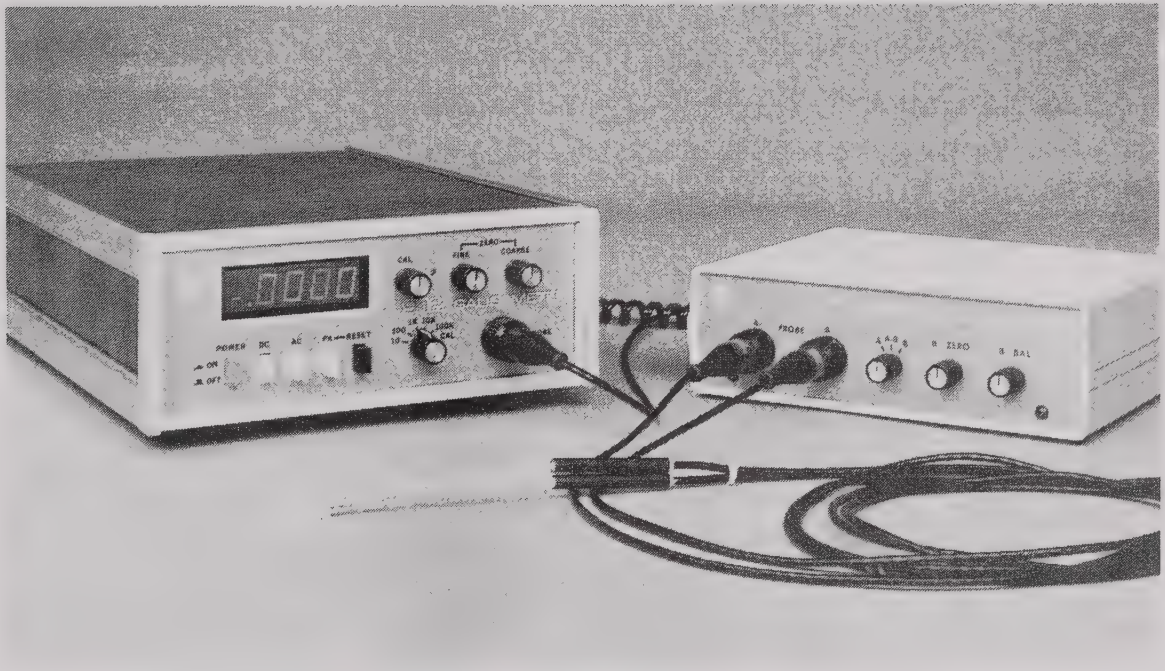


Figure 1. Model 912 with Model 913 Differential Adaptor (bench-top configuration)

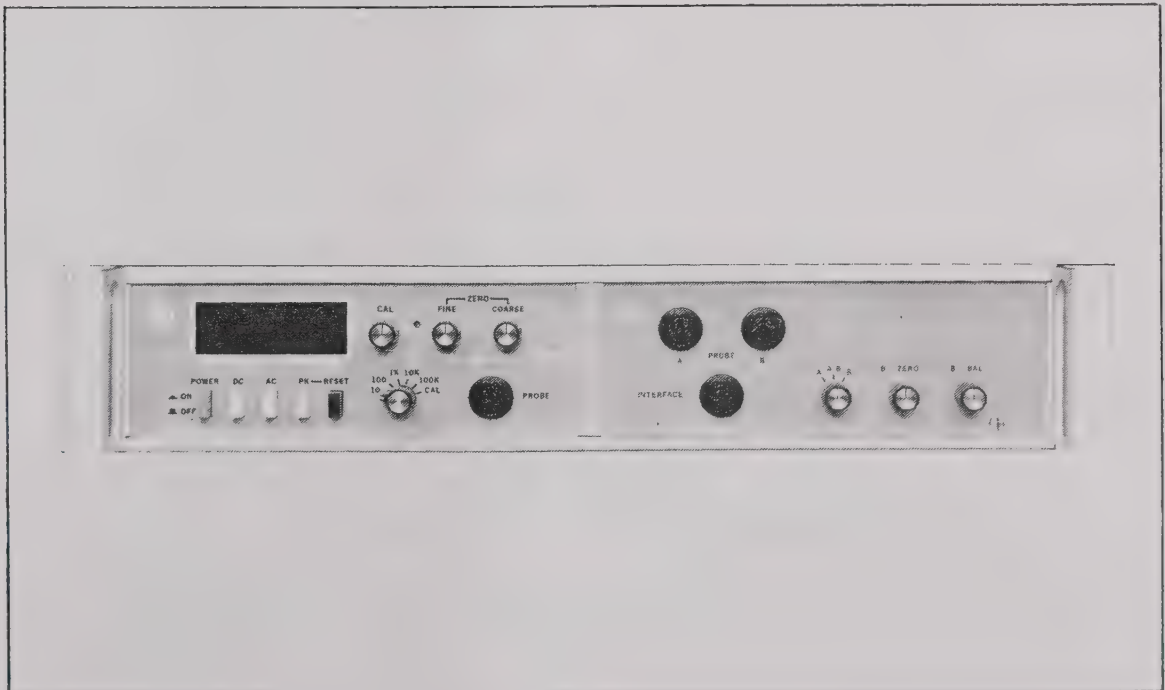


Figure 2. Model 912 with Model 913, rack-mounted

Chapter II

SPECIFICATIONS

Full-Scale Ranges: 10, 100, 1K, 10K, and 100K Gauss. 100% overrange on all but 100K Range.

Modes of Operation: Permanent Magnet/DC, AC and Peak.

DC Accuracy: $\pm(0.4\%$ of reading $+0.1\%$ of range $+1$ digit).

AC Accuracy: Average sensing - peak reading indication.

40-400 Hz $+(1.5\%$ of reading $+0.5\%$ of range)

401-800 Hz $+(4\%$ of reading $+1\%$ of range)

801-1000 Hz $+(6\%$ of reading $+1\%$ of range)

(Total accuracy without probe)

Peak Reading Accuracy: $\pm(0.8\%$ of reading $+0.2\%$ of range).

Peak reading mode applies to static (PM or DC) fields only. Decay time of indication does not exceed 0.1% in ten seconds after peak reading is obtained.

NOTE: All accuracy specifications apply for a 4-month calibration cycle and an ambient operating temperature of $24^{\circ}\text{C} \pm 4^{\circ}\text{C}$ at relative humidity between 30% and 80%. Specifications apply for reading between 5% and 199% of range.

Operating Temperature: 0°C to 40°C .

Temperature Coefficient: Less than $0.05\%/^{\circ}\text{C}$ (instrument only)
Hall probes have their own T.C. which is usually on the order of 0.1 Gauss/ $^{\circ}\text{C}$.

Size: Bench-mount unit; 8.5" w x 13" d x 4" h (21.6 cm x 33 cm x 10.2 cm).

Weight: 6.56 lbs. (3 kilograms).

Power Requirements: 115 or 230 volts $\pm 10\%$ (switch selectable)
48 to 63 Hz. Power Consumption: 14 VA Typical.

Rear-Panel Connections: Analog output via BNC connector; +5 volt for full-scale range. Accuracy as stated above plus 0.2% of range. Analog output not directly calibrated when Model 912 is in AC Mode. AC field waveforms may be observed from analog output with instrument in DC mode.

Options: BCD parallel (1-2-4-8), TTL-compatible, logic levels.
IEEE-488 Bus.

Differential measurement using RFL Model 913 Differential Adaptor.

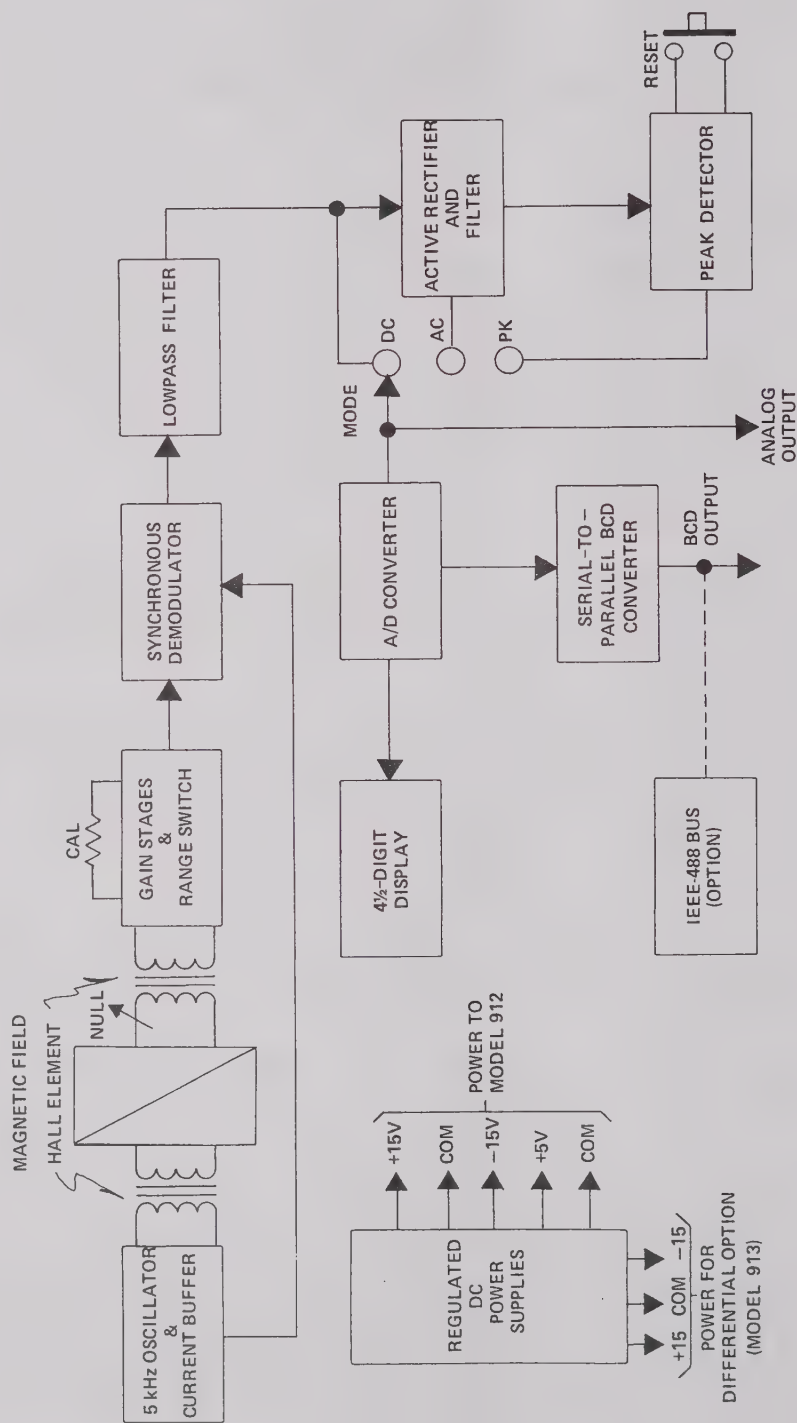


Figure 3. Block diagram of gaussmeter circuit

Chapter III

THEORY OF MEASUREMENT

GAUSSMETER

The block diagram shown in Figure 3, shows the arrangement of major circuit functions in the Model 912.

At the left of Figure 3, a variable-state oscillator generates a signal whose frequency is 5 kHz. Its output is current-buffered, providing excitation to the Hall probe through an isolation transformer. In series with the primary winding of the transformer is circuitry which allows the user to perform COARSE and FINE ZERO adjustment of the probe signal. At the same time, 5 kHz is applied to the demodulator circuit, for detection of the Hall probe output signal.

A second, isolation transformer is used to couple the output signal of the Hall probe to the input of the gain stages which contain the range selection circuitry. Gain calibration is accomplished by a potentiometer; one for each range. The field-sensitive, analog-signal output is full-wave rectified by a synchronous demodulator, yielding a phase-sensitive, plus or minus level proportional to the polarity and magnitude of the magnetic field being measured.

In the event that high-frequency ripple or noise is present on the output of the synchronous demodulator, it will be removed by the characteristic transfer function of the lowpass filter circuit. The output of the lowpass filter goes through a non-inverting stage (gain of 5), then feeds the DC MODE select pushbutton, and the active rectifier; the purpose of which is to provide the desired rectified and filtered output to the AC MODE select pushbutton switch and the peak detector circuit.

A means of storing peak readings is afforded by the peak detector (sample-and-hold) circuit. This circuit receives its input from the active rectifier and filter, and will hold the maximum reading until the operator depresses the momentary RESET pushbutton switch. The peak reading can only be measured when the PK (peak) MODE pushbutton switch is selected.

Upon selecting the desired MODE i.e., DC/AC/PK, the corresponding signal will be fed to the rear-panel BNC ANALOG OUTPUT connector and also, to the A/D converter which provides the digital conversion required to drive the 4½-digit display and the serial-to-parallel BCD converter, the latter of which is an equipment option.

The power supply is of conventional design and is powered through an isolation transformer. Three, regulated voltages are provided: plus 15 Vdc, minus 15 Vdc, and plus 5 Vdc.

Binary-coded-decimal (BCD 1-2-4-8) signals corresponding to the displayed measurement are available as an optional output signal. The BCD OUTPUT, 25-pin, rear-panel connector has the following signal assignments (Table 1).

Table 1. Rear-Panel BCD Output Connector - Pin Assignments			
Pin	Function	Pin	Function
22	Polarity	4	BCD 1000
1	BCD 1	5	Dec. Point X.XX (+5)
19	BCD 2	18	Reserved
14	BCD 4	10	Ground
7	BCD 8	6*	Reset (Hold Display)
2	BCD 10	17*	Data Ready
20	BCD 20	13	Over Range (If Desired)
15	BCD 40	25	Reserved
8	BCD 80	12	Reserved
3	BCD 100	24	Reserved
21	BCD 200	11	Reserved
16	BCD 400	23	Reserved
9	BCD 800		
*When the Model 912 is equipped with the 488 Bus option, a jumper wire must be added which will change the signal path. See IEEE-488 Bus manual for details.			

THE HALL EFFECT

When electrons move in a conductor perpendicular to a magnetic field, they are deflected toward one side of the conductor (left or right depending on the direction of the magnetic field) in a direction normal to the direction of both the initial electron flow and the magnetic field. The force deflecting the electrons is directly proportional to the electron velocity (current) and the magnetic field intensity. This deflection process continues until sufficient charge has accumulated at the sides of the conductor to establish a transverse electric field which opposes further deflection of charge carriers. The transverse potential difference thus created is called the Hall voltage and the phenomenon causing it is known as the Hall effect.

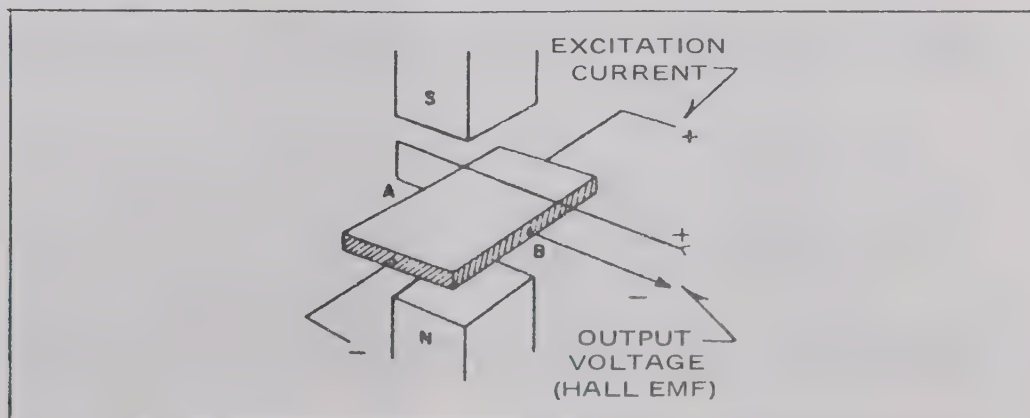
The magnitude of this potential in volts is given by
$$E = \frac{RIH}{t},$$

where E is the Hall voltage, H is the magnetic flux density in Oersteds, t is the thickness of the sample in centimeters, R is the Hall coefficient in volt-cm/ampere gauss, and I is the applied current.

Under the conditions shown in Figure 2, terminal B will be negative with respect to terminal A for metals and semiconductors in which the current is carried by electrons. Reversing the field reverses the output polarity. As shown by the equation above, the width of the strip is not a factor of the output as long as it is large compared to the thickness. The strip should be twice as long as it is wide or the output drops off. For thin strips, the output is unaffected by the frequency of the field in the audio range. The Hall voltage is maximum when the plane of the element is perpendicular to the magnetic field.

Practical materials for Hall elements are films and slabs of specially refined semiconductors. The sensitivity, temperature stability and linearity to fields can be varied through wide ranges by selection of materials. One characteristic can usually be improved at the expense of another.

The output voltage from a gaussmeter probe is proportional to the excitation current, and if this current is held constant then the Hall voltage will be solely proportional to the incident magnetic flux, although the precise Hall voltage for constant flux may vary slightly from one probe to the next. Probes supplied for use with the Model 912 are standardized at the factory, for use with this instrument, by marking them with a number which compensates for this variation. Then, the instrument is calibrated by varying the gain of the voltage amplifying section until the meter reads the number stamped on the probe.



Chapter IV

OPERATING INSTRUCTIONS

CAUTION

To avoid exposure to hazardous voltages, observe procedures given in pages iii and iv.

INSTALLATION

Determine whether the instrument is to be operated from 115- or 230-volt primary power. The instrument is shipped from the factory with the voltage-selector switch, S7 (Figure 11) set at the 115-volt position, and with a fuse rated for 0.25 ampere at F300 (Figure 5). For operation from 115 Vac, the instrument need only be connected to the power source. If the instrument is not set-up for the desired operating voltage perform the following installation procedure:

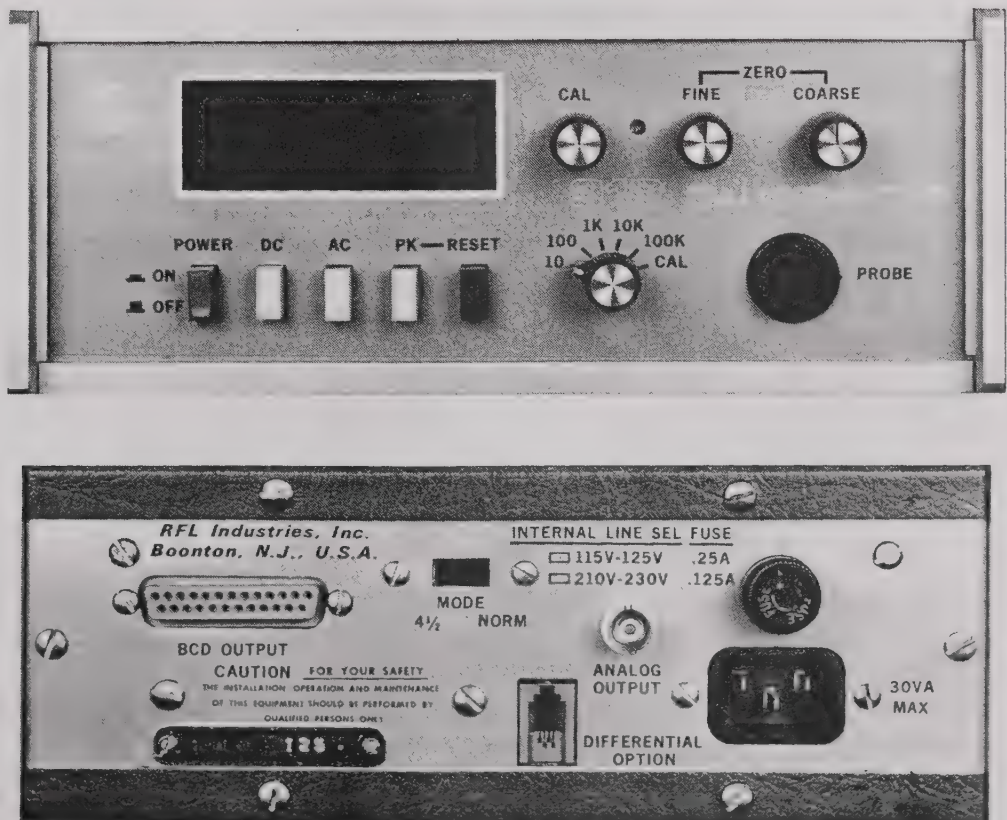


Figure 5. Front and rear panels of Model 912

INSTALLATION PROCEDURE

1. Be certain that the Model 912 is NOT connected to a 115 or 230 volt line source.
2. Remove the two fastening screws at the rear of the top cover plate, refer to Figure 9. Slide the cover off the instrument and check the position of the line-voltage selection switch which is located adjacent to the power transformer. This a two-position slide switch and will indicate a figure of either 115 or 230. The figure which shows will indicate the line voltage at which the unit will operate. Desired operational line voltage may be changed by sliding this slotted switch lever so that the desired figure is displayed.

NOTICE: The Model 912 is designed to operate on either 115 or 230 volts where the supply is a two-wire system (hot and neutral) plus a third grounding lead. This is the type of 115 volt line normally encountered in the United States. When the instrument is to be operated on a 230 volt line a modification must be made by cutting a jumper wire on the Model 912 circuit board. This insures that both sides are in the On-Off switch circuit. See Table 2 for details.

Table 2. Summary of Line - Voltage Changes		
Input Line Voltage (Refer to Figures 11 and 15)		
	115 Vac Operation	230 Vac Operation (two hot wires)
Line Voltage Select Switch (S7)	115V position	230V position
Fuse, F300 (Amperes)	0.25A	0.125A
Jumper, J2	IN	OUT
*For countries using metric-size (5 mm x 20 mm) fuses, an appropriate fuse carrier will be supplied; RFL P/N 90278.		

3. Check the rear-panel fuse to be certain that it is the appropriate component for the line voltage selected; 0.25 ampere for a 115 volt line or 0.125 ampere for a 230 volt line. The Model 912 is equipped with a fuse holder that will accept a type 3AG fuse or a metric-size (5mm x 20mm) fuse. The fuse should be the "slo-blo" type to enable it to handle the small inductive surge which may occur when the instrument is switched on.
4. Replace the top cover and its retaining screws. Be sure that the removable line cord is securely seated in the line receptacle on the rear panel. Plug the line cord into an appropriate power outlet.

GENERAL OPERATION

1. Plug the desired Hall-effect probe into the front-panel receptacle; see probe section which follows for a description of the types of probes available.
2. Select the number of digits you wish to be displayed by placing the rear-panel slide switch to its appropriate position, i.e. NORM or 4-½. In NORM position the Model 912 display will consist of 3 ½ digits.
3. Place the rotary Selector switch in its 1K position, press the red POWER pushbutton in to energize the instrument, and depress the DC pushbutton. The Model 912 display should become illuminated.
4. Set the FINE and COARSE ZERO controls to their centers of rotation - since each of these is a ten-turn potentiometer, center will be five turns from either full clockwise or full counter-clockwise rotation. Follow the same procedure in setting the CAL position initially.
5. It is advisable to place the Hall probe tip into a zero-gauss chamber for zero adjustment if measurements of less than 100 gauss are to be made since stray fields can range from 0.4 gauss (the earth's ambient) to several gauss; depending on other stray magnetic fields. The RFL type HA-16580 dual-shield Zero-Gauss Chamber is highly recommended. **NOTE:** Zeroing should always be done in DC mode, never in AC or PK.
6. With the Selector switch still in its 1K position, rotate the COARSE ZERO control until the display indicates .0000 then place the Selector switch to 100 gauss position; adjust both COARSE and FINE ZERO controls for 00.00 indication. Final zero adjustment is made with the range Selector set to 10 gauss and the FINE and COARSE ZERO controls are carefully adjusted until the readout indicates 0.000. **NOTE:** If the rear panel 4 ½ - NORM switch is set to NORM the indications will

be similar to those described above, less one zero; i.e. 0.00 on the 10 gauss range.

If the COARSE control is adjusted so that the instrument goes beyond overrange (by misadjustment of the control) the display will consist of a row of flashing zeroes.

7. **CALIBRATION:** Place the range Selector in CAL position. Note the CAL number on the Hall-effect probe plug. If the Model 912 display indicates a value relatively close to this figure merely adjust the CAL control until the probe CAL figure is indicated on the readout. If greater adjustment is required, return the CAL control to the center of its rotation and adjust the slotted control adjacent to the CAL control using a small screwdriver. This control is an 18-turn potentiometer. Adjustment should be made until a reading close to the CAL indication on the plug is achieved. Final adjustment should be made using the CAL control. The instrument is now ready to use for measuring Permanent Magnet, DC or AC fields. The peak of a DC or PM field may also be measured.

NOTE: Always zero balance the Gaussmeter in its DC Mode.

8. In AC Mode the Model 912 uses average sensing, but the readout is scaled for Peak value. Therefore, the waveshape of the AC field which is to be measured must be sinusoidal with a low value of distortion.
9. **PEAK Mode of Operation:** This mode is used to measure the highest value of a varying DC or Permanent Magnet field. It is effectively, a sample-and-hold circuit. After a peak value is read the RESET button must be momentarily pressed to restore the readout to zero prior to making another reading. This mode of operation is especially useful where the gap in a measured field has little or no "plateau". In normal operation it would be difficult to determine the highest value of flux density in the gap. The PEAK Mode simplifies this type of measurement.
10. **Polarity Indication:** The absence of any polarity indication in front of the first significant figure of the display should be considered a Positive (+) response. A reverse polarity reading will be indicated by a minus (-) sign preceding the first digit. The Positive indication may be considered a North pole reading and the Minus a South pole.

Polarity indications are operational only when the DC Mode is used. In AC and PEAK the display indication will not be preceded by any polarity mark.

Chapter V

PROBES

The Model 912 uses Hall-effect probes for measuring flux density. RFL has twelve standard Hall-effect probes available for use with this instrument; see Figure 6. Questions on choice and application of probes, as well as questions on unusual applications may be directed to RFL's Magnetism Engineering Department.

NOTE: Test data sheets are supplied with every probe. These contain electrical and temperature-stability values plus calibration data for each range of the instrument on which they are used. It is important when ordering replacement probes that the model and serial number of the Gaussmeter be provided. This will assure proper calibration and assembly of the correct connector.

Flat or Transverse-Field Probes

The transverse Hall-probe measures magnetic fields perpendicular to its flat surface. RFL flat probes are supplied in thickness ranging from 0.015 inch to 0.039 inch. The 0.025 and 0.039-inch probes are enclosed in rugged fiberglass/epoxy shields to provide maximum protection for the sensitive Hall element. All flat probes incorporate a pencil-slim handle and semi-flexible leads from the element to enable use in a wide variety of applications. A lightweight, five-foot cable is standard with all flat probes.

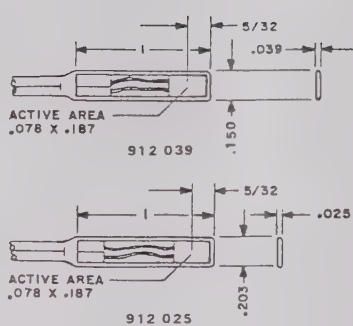
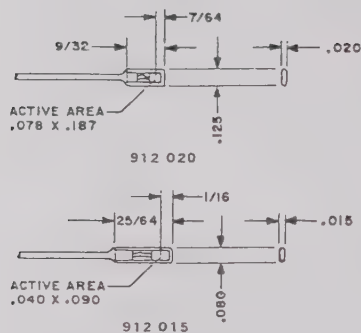
Axial Probe

This configuration is used to measure fields parallel to the probe handle, such as solenoidal fields. The Hall element is encapsulated in epoxy and the handle is rigid for several inches beyond the tip. Various sizes are available. The axial probe, because of its tip construction, is generally less subject to accidental damage than flat probes. However, care must be exercised not to allow the flat face of the tip to contact abrasive surfaces where any motion is involved. The Hall element is located only a few thousandths of an inch behind the face and could be damaged if undue pressure is placed on it.

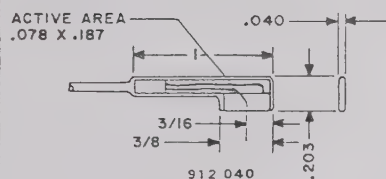
Tangential Flat Probe

The tangential probe is similar to the flat probe with the main difference being the element is placed as close to the edge of the tip as possible. The flat-probe element is centered between the outside edges of its enclosure. This construction places the element in close proximity to the outside edges of the enclosure. Care must be taken, therefore, that the probe will not be subjected to rough handling.

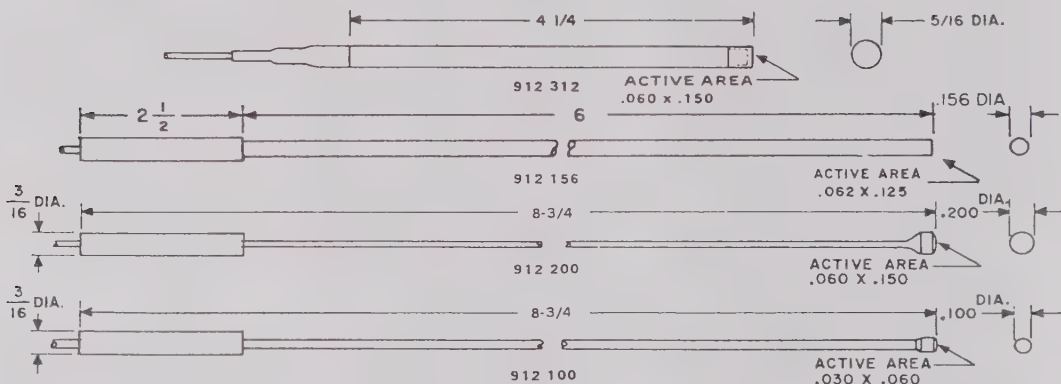
FLAT PROBES



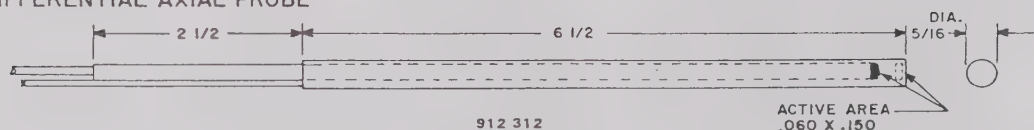
TANGENTIAL PROBE



AXIAL PROBES

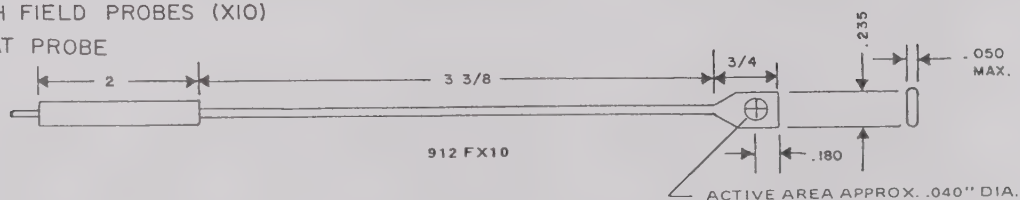


DIFFERENTIAL AXIAL PROBE

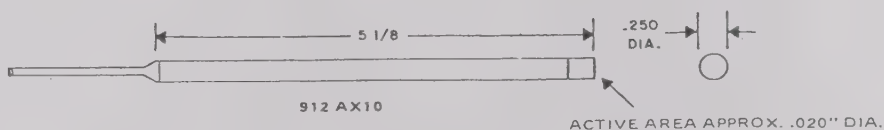


HIGH FIELD PROBES (X10)

FLAT PROBE



AXIAL PROBE



Temperature Characteristics

Temperature characteristics of probes vary slightly between types and between individual probes.

The maximum change that can be expected is approximately 1 gauss/10°C. All probes may be used in the temperature range of -60°C to +95°C.

NOTE: 1. A wide range of probe configuration available for special applications on request.

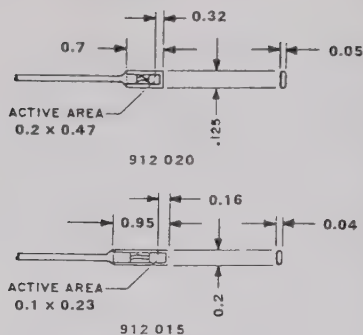
2. All probes are supplied with a connector and a 5 foot cable. Extension cables available.

3. RFL reserves the right to change probe dimensions as required.

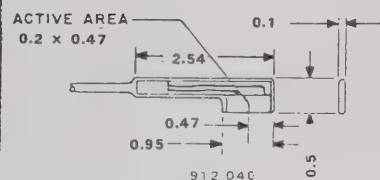
4. All dimensions are in inches

Figure 6 (a). Standard gaussmeter (Hall-effect) probes - English dimensions

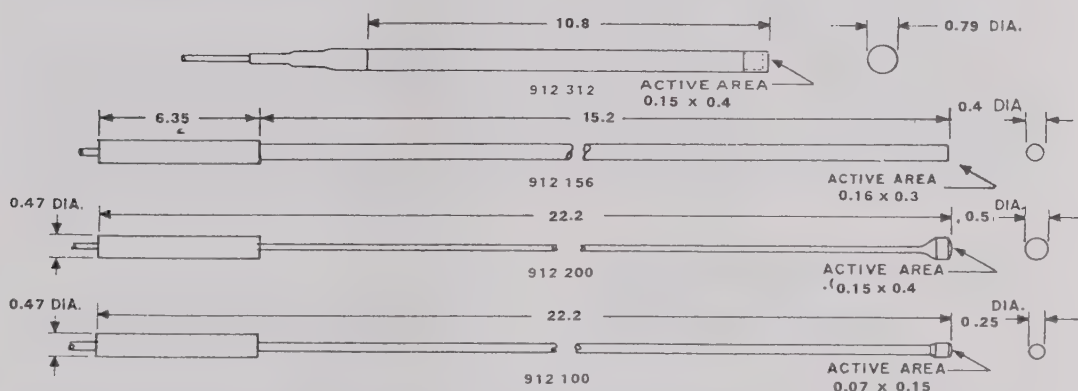
FLAT PROBES



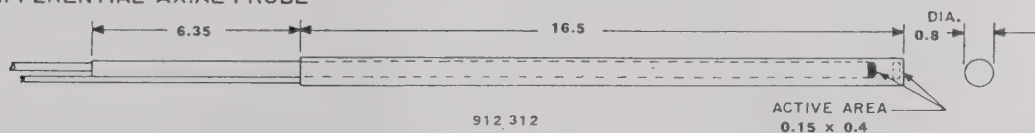
TANGENTIAL PROBE



AXIAL PROBES

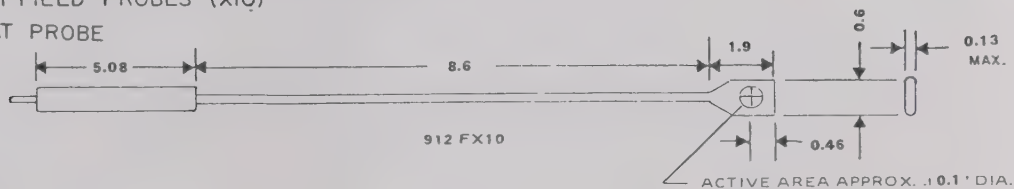


DIFFERENTIAL AXIAL PROBE

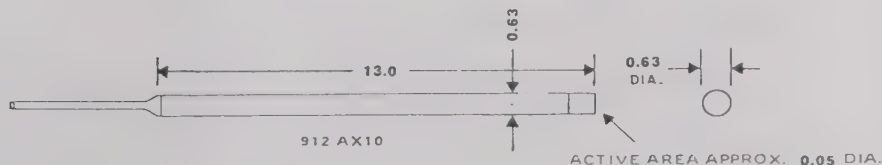


HIGH FIELD PROBES (XIQ)

FLAT PROBE



AXIAL PROBE



Temperature Characteristics

Temperature characteristics of probes vary slightly between types and between individual probes.

The maximum change that can be expected is approximately $1 \text{ gauss}/10^\circ\text{C}$. All probes may be used in the temperature range of -60°C to $+95^\circ\text{C}$.

NOTE: 1. A wide range of probe configuration available for special applications on request.

2. All probes are supplied with a 1.5 meter cable. Extension cables available.

3. RFL reserves the right to change probe dimensions as required.

4. All dimensions are in centimeters.

Figure 6 (b). Standard gaussmeter (Hall-effect) probes - metric dimensions

The tangential probe is used for measuring tangent to the surface of a material where it is necessary to place the probe element as close to the surface as possible. This enables measurements of flux densities close to and parallel to a surface where either flux leakage or anomalies in the material occur.

Differential Flat Probes

The Differential flat probe is comprised of two matched probes. Construction is identical to the flat probe already described. The only difference is that these probes are electrically balanced so that their readings are within $\pm 1\%$ of each other. Differential probes can be made up with any pair of flat probes.

The most general application for this type probe is for measuring gradients in a field at two different points simultaneously. Differences between two separate fields can also be measured simultaneously by placing the probe in each field.

A spacer block is supplied which enables different spacing to be employed between probes for various measurements and to facilitate ease of calibration. These probes can also be used for individual probe measurements since they are both independent of each other.

Differential Axial Probe

This probe was designed to be used in the differential mode of operation on the Model 913 Differential Adaptor. Differential Axial field gradient measurements are usually encountered with objects such as solenoids and ring magnets. It is also used for measuring differences between two similar fields. The differential axial probe was designed with one element placed behind the other. The first element, closest to the probe face, is permanently fastened in place. The second element is built as a separate probe and can be completely removed from its epoxy encasement. This enables both probes to be used for single probe measurements and to vary the spacing between them. This type of construction enables a higher degree of versatility and results in a major cost savings since additional probes are not required for other applications.

High Field Probes (X10)

These probes are for use on the Model 912 Gaussmeter to allow the measurements of high-density fields in excess of 15 kilogauss. Linearity error is within ± 1.5 percent. Probes are available in two configurations: flat and axial. All readings are attenuated by a factor of 10; and therefore must be scaled accordingly by multiplying by 10.

Chapter VI

CALIBRATION AND MAINTENANCE

CAUTION

To avoid exposure to hazardous voltages, observe procedures given in pages iii and iv.

Calibration

Calibration of the Model 912 will require access through the top of the instrument to adjustments and components on the circuit boards. Reference to Figure 9 will facilitate removal of the top cover. Figures 10 and 11 will facilitate location and identification of adjustments, connectors, and test points located on the upper and lower boards respectively. Adjustments should be made in the sequence of the following procedure.

NOTE: All 100 series components, e.g. R102, C101 etc., are located on the upper board. Components below 100, e.g. R24, C18 etc., are located on the lower board.

Equipment Required

1. Digital Voltmeter (Keithley 191 or equal)
2. Oscilloscope
3. Test Plug with 1 ohm $\pm 0.01\%$ resistor, see Figure 7.

NOTE: The plug, consisting of a four-pin connector housing, a connector cover, and four connector pins, are manufactured by Amp Inc., and are part numbers 207313-1, 207314-1, and 207438-3 respectively. The 1 ohm, 0.5W, 0.01%, wire-wound resistor is connected between pins 3 and 4 of the plug and pins 1 and 2 are shorted together as shown below.

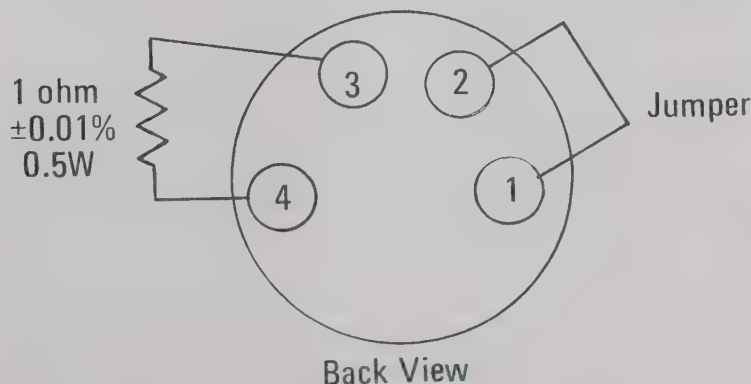


Figure 7. Test Plug connections (1 ohm).

If the above test plug is not available or cannot be readily assembled, a precision AC current meter capable of performing at 5 kHz can be used instead. When the current meter is used, it is connected across pins 3 and 4 of connector J200 (PROBE socket) on the front panel of the Model 912.

4. Test Plug with two resistors, 1K ohms $\pm 0.05\%$ and 520 ohms $\pm 0.05\%$, see Figures 8.

NOTE: The Test Plug can be assembled as follows:

- (a) Using a Molex connector (P/N 15-04-0219), connect a 1K-ohm, 0.25W, 0.05% resistor between pins 1 and 3.
- (b) Similarly, connect a 520-ohm, 0.25W, 0.05% resistor across pins 4 and 5.
- (c) The required Molex pins are P/N 08-0105; four are required.

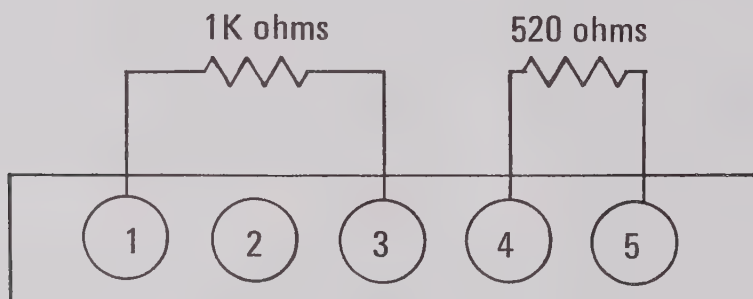


Figure 8. Test Plug connections (1K ohm/20 ohms).

If the above test plug is not available or cannot be readily assembled, the following option is recommended:

- (a) Turn off power to Model 912 and disconnect power cord.
 - (b) Remove plug P2 from lower PC board.
 - (c) Connect precision digital ohmmeter across pins J2-5 and J2-4 (on the female Molex connector).
 - (d) Adjust potentiometer R141 for a resistance of 520 ohms $\pm 0.05\%$.
 - (e) Connect ohmmeter across pins J2-1 and J2-3.
 - (f) Adjust R140, on the front panel, for 1K ohms $\pm 0.05\%$.
 - (g) Continue with Step 13 of Calibration Procedure.
5. DC Calibrator, nominal accuracy $\pm 0.005\%$.
 6. 100 Gauss reference magnet, RFL Type F343-100, or equal.
 7. 1000 Gauss reference magnet, RFL Type A312-1K, or equal.
 8. 10,000 Gauss reference magnet, RFL Type F040-10K, or equal.

9. Dual-shield, zero-gauss chamber, RFL Type 16580, or equal.
10. Multimeter, Simpson 260, or equal.
11. Standard probe with $10 \text{ mV} \pm 1\% / 1000 \text{ gauss}$ with 100 mA drive current, unloaded.

NOTE: The Model 912 was factory calibrated using reference magnets and a probe standard. The user is advised that use of a probe with open circuit magnetic sensitivity other than $10 \text{ mV} \pm 1\% / 1000 \text{ gauss}$ at 100 mA current drive may effect calibration accuracies.

CALIBRATION PROCEDURE

1. Do not connect power cord to Model 912 until instructed to do so. Check to see that slide switch, S7, on lower board is set to 115 Vac (or 230 Vac, if applicable), and Mode switch on rear panel is set to $4\frac{1}{2}$. Place the test plug with the 1-ohm resistor into the front-panel PROBE socket (J200).
2. On the DC Calibrator, turn on power and connect the positive output to TP101 and the common to TP11. Set the calibrator to $+5 \text{ Vdc} \pm 0.005\%$ (4.99975 to 5.00025 Vdc) output.
3. Connect the Model 912 to a 115 Vac, 60-Hz power line and depress the POWER ON button. Set Range to 1K gauss.
4. Using the calibrator, adjust R116 for a reading of $1.0000 \pm 2 \text{ LSD's}$ on the Model 912 display.
5. Set the calibrator to 1.0 Vdc, the Model 912 display should read $.2000 \pm 5 \text{ LSD's}$.
6. Set the calibrator to +9.0 Vdc, the display should read $1.8000 \pm 5 \text{ LSD's}$.
7. Set the calibrator for -5 Vdc, the display should read $-1.0000 \pm 6 \text{ LSD's}$. Disconnect the calibrator from the gaussmeter.
8. Place the DC MODE switch to the IN position, connect the digital voltmeter across 1-ohm resistor on test plug. Measure 0.10000 volts AC $\pm 5 \text{ LSD}$, adjust R67 for this reading.
9. Remove P2 (lower board) and replace it with the resistor plug (1K ohm and 520 ohms). Place Range switch to 10-Gauss Range.
10. Adjust COARSE and FINE controls to their center positions, (they are both 10-turn potentiometers) the front-panel display should be close to a zero reading, if not, readjust the COARSE and FINE controls.

11. Place Range switch to 100K gauss, adjust R1 for zero ± 2 digits on front-panel display.
12. Place Mode switch to AC and adjust R13 for zero on front-panel display, ± 2 digits.
13. Place Mode switch to PK and with RESET switch depressed, adjust R79 for zero ± 2 counts on the front-panel display. Return to DC with mode switch.
14. Remove the test plug from front-panel socket and replace it with a standard Hall test probe.
15. Select 100-gauss range, place probe in zero-gauss chamber, and adjust COARSE and FINE controls to zero reading on front-panel display.
16. Place Range switch to 10 gauss and readjust COARSE and FINE controls for zero reading on front-panel display.
17. Place Range switch to 1K-gauss position.
18. Remove probe from zero-gauss chamber. Place it in the 1K-gauss standard magnet, measure for a peak magnetic field and hold probe in that position while adjusting R33 for the reference magnet calibration figure ± 2 counts.
19. Holding the Hall probe in the same position as in Step 18 set Range switch to 10K gauss and adjust R35 for reference magnet calibration figure ± 1 count.
20. Place Hall probe in a 10K-gauss standard magnet and find peak magnetic field, note reading on display.
21. Switch to 100K-gauss range and adjust R32 for the reading observed in Step 20. You may have to switch back and forth to obtain reading.
22. Place Hall probe in zero-gauss chamber, set to 10-gauss range, and adjust FINE and COARSE controls for zero reading on front-panel display ± 2 counts.
23. Switch the Model 912 to 1K-gauss range, place Hall probe in 100-gauss reference magnet. Find peak magnetic field, note reading on display.
24. Set Range switch to 100 gauss and adjust R36 for a reading obtained in Step 23 with Hall probe held in same position as in Step 23, ± 1 count.
25. Place probe in zero-gauss chamber set to 10-gauss range and adjust COARSE and FINE controls to zero ± 2 counts.
26. Place Range switch to 100-gauss range, place Hall probe in 100-gauss reference magnet. Adjust the Hall probe for a 10 to 18 gauss reading on the front-panel display of the Model 912.

27. Set the Range switch to 10 gauss and adjust R34 for same reading obtained in Step 26 ± 2 counts (between 10 and 18 gauss).
28. Set Range switch to CAL and adjust R60 for .8334 ± 3 counts on display.
29. Remove P2 resistor plug (1K and 520 ohms) and replace it with the mating Model 912 Molex plug. While in CAL position adjust R140 and R141 to full clockwise position and observe minimum reading of 1.2000 ± 50 counts, then adjust R140 and R141 full counterclockwise and observe a minimum reading of .4500 ± 50 counts.

NOTE: If you did not use the resistor plug, disregard the first sentence of Step 29 and start with the second sentence of Step 29.

30. Adjust R140 (ten-turn potentiometer) and R141 (18-turn potentiometer) to their mechanical centers.
31. Select 1K-gauss range, place probe in zero-gauss chamber and note zero ± 2 counts on display, set Range switch to 10 gauss range, adjust COARSE and FINE to zero on front-panel display ± 2 counts.
32. Set the Range switch to 1K-gauss range, place Hall probe in 1K-gauss reference magnet and find peak field. Adjust front-panel CAL control for 1K gauss ± 2 counts on front-panel display. If the display reads more than ± 200 counts away from 1K gauss, adjust the COARSE control first to get it close to 1K gauss and then adjust FINE R140 to bring it in. Adjust CAL for reading of 1.0000 ± 2 counts.
33. Place Mode switch to AC and adjust R14 for 1.5708 ± 5 counts.
34. Place Mode switch to DC and verify 1K reading ± 2 counts. If reading is out of tolerance readjust CAL (R140) for 1.0000K gauss ± 2 counts and repeat Step 33, if no change, continue to Step 35.
35. Set Mode switch to PK, press reset and adjust R15 for 1000 gauss ± 5 counts; while holding reset in.
36. Place Mode switch to DC, see that the front-panel display still reads 1.0000K gauss, if not, readjust CAL (R140) for 1.0000K gauss, then repeat Step 35.
37. Place Mode switch to DC, connect DC voltmeter to ANALOG OUTPUT, BNC connector on back panel. With display reading 1.0000K gauss ± 2 counts the DC voltmeter should read 5 Vdc $\pm 0.25\%$ (max. 5.0125 - min. 4.9875).

38. Place Hall probe into the zero-gauss chamber. Set the Range selector to 10 gauss and adjust the COARSE and FINE controls for zero.
39. Remove Hall probe from magnet and re-insert it back into magnet in the reverse polarity and find peak field again. Display should indicate $-1.0000\text{K gauss} \pm 12.5$ counts.

MAINTENANCE and REPAIR

Maintenance of this instrument should require no more than periodic recalibration to assure its continued accuracy. Six-month intervals are suggested. Equipment may be returned to RFL for recalibration, and for repair if needed.

Failure of the equipment to perform properly is usually evidence of some defect in either the procedure used or in the equipment, and it is well to determine which at the outset.

When the equipment is at fault, the nature of the failure is a most valuable symptom. An understanding of the organization of the circuits, as shown in Figure 3 will help to suggest the general area of the fault, which usually can be localized with the aid of the circuit schematic (Figures 12-15) and voltage measurements. Signal tracing with an oscilloscope is also a powerful approach.

In order to remove the top or bottom covers, or the unit from the side panels, follows these instructions. Refer to Figure 9.

1. To remove top cover, remove two screws from the top of the back panel and slide top cover to the rear.
2. To remove bottom cover, remove two screws from the bottom of the back panel and slide bottom cover to the rear.
3. To remove the unit from the side panels (after top and bottom covers are removed), remove two screws from the top front rail. This rail is interlocked with the front panel. Remove two screws from the right and left of the back panel, which will then release the unit from the side panels. The case may be removed by holding front and rear panels and pulling up. The internal circuits plus front and rear panel will separate from case.

Troubleshooting Checks

1. Before applying power do a visual check of the unit for shorts, broken wires, and any other abnormal condition that can be found by a visual examination. With an ohmmeter check for shorts between +5 Vdc (TP12), +15 Vdc (TP10), -15 Vdc (TP9) and ground (TP11).

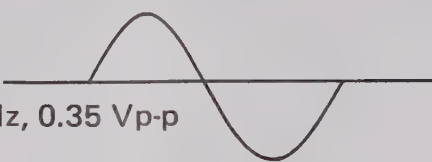
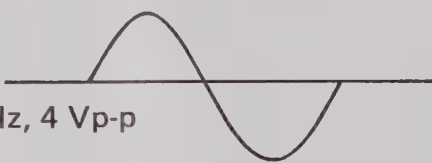
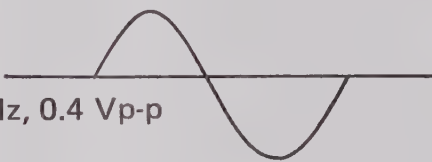
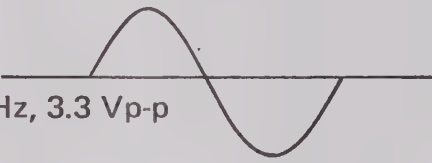
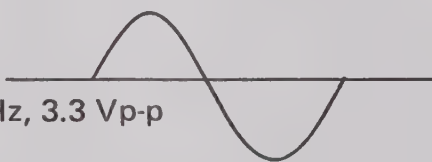
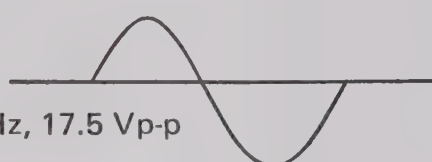
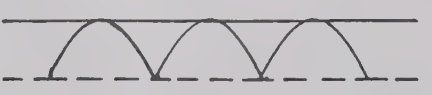
2. Connect the Model 912 to a 115 Vac, 60-Hz power line and depress the POWER ON button.
3. Place all other switches to off position (out) and allow unit to warm up for at least ten minutes.
4. Using a digital voltmeter measure the voltages between TP11 (common) and TP12 (+5 Vdc), TP10 (+15 Vdc), and TP9 (-15 Vdc). All voltages should be within $\pm 5\%$.
5. Connect the high side of oscilloscope to TP8 and the low side to TP11. Observe a 5-kHz sinewave (period 200 microseconds) with a peak-to-peak amplitude of $18 \pm 0.9\text{V}$. The frequency should read $5000 \pm 250\text{ Hz}$.
6. COARSE/FINE ZERO adjust (perform check if required): Place range switch of Model 912 to 100 gauss, adjust COARSE and FINE controls on front panel to full clockwise position, observe a minimum reading of 35 gauss on the front-panel display. Adjust COARSE and FINE controls to full counterclockwise position, observe a minimum of -35 gauss on front-panel display. Note that this should be done with a short across Pins 1 and 2, and a short across Pins 3 and 4 of socket J200.
7. Place Mode switch to DC, set the Range switch to 1K gauss and place the probe into a 1K-gauss DC or PM field. Display should indicate +1000 gauss ± 125 counts. Check for the following waveforms and voltages; per Table 3. This table contains voltage, waveform, and timing data for strategic points in the circuit, and are listed in a logical signal flow from input to output. Use of Table 3 in conjunction with the schematic diagrams are recommended.

NOTE:

For data in Table 3 to be valid, the following conditions must be satisfied:

- (a) Select DC Mode only.
- (b) Select 1000-gauss range.
- (c) Probe must be in a 1K-gauss field.
- (d) A positive-gauss, full-scale reading should always be observed on the display.

Table 3. Waveforms and Voltages at Selected Points

Test Point	Observation
Cathode of CR9	 5 kHz, 0.35 Vp-p
IC10-6	 5 kHz, 4 Vp-p
TP5	 5 kHz, 0.4 Vp-p
TP6	 5 kHz, 3.3 Vp-p
TP7	 5 kHz, 3.3 Vp-p
TP8	 5 kHz, 17.5 Vp-p
IC3-7	 5 kHz 5V 0V
TP2	 1.7V 0V
TP1	
IC1B-7	1 Vdc 5.0 Vdc

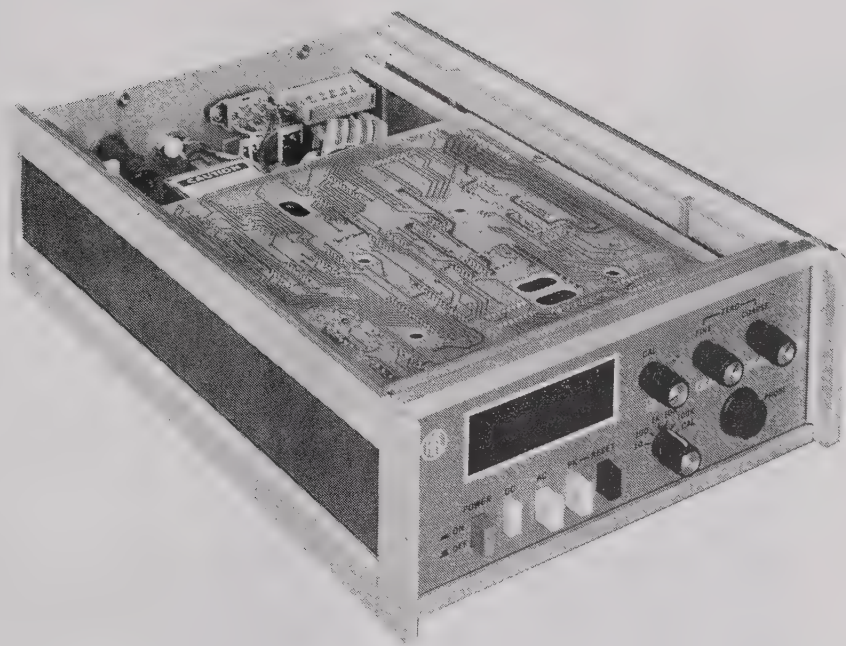


Figure 9. Model 912 with top cover removed

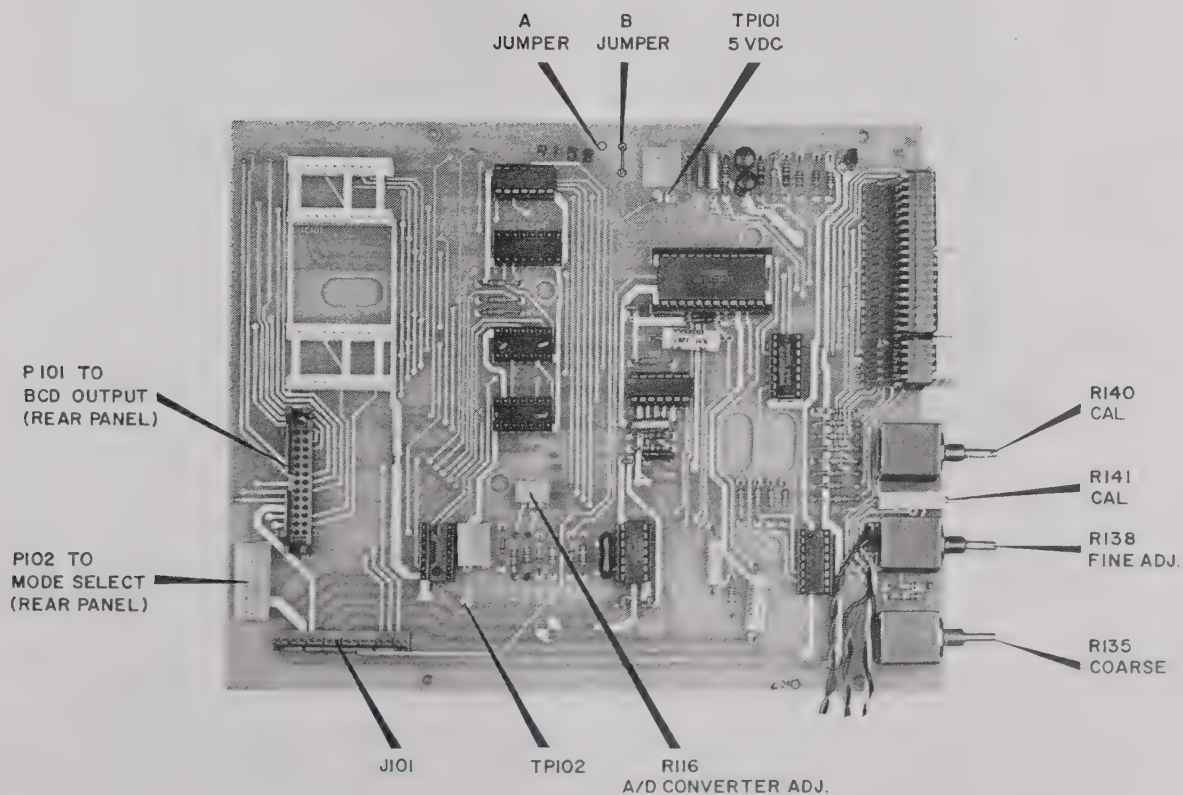


Figure 10. Components and adjustments on upper board

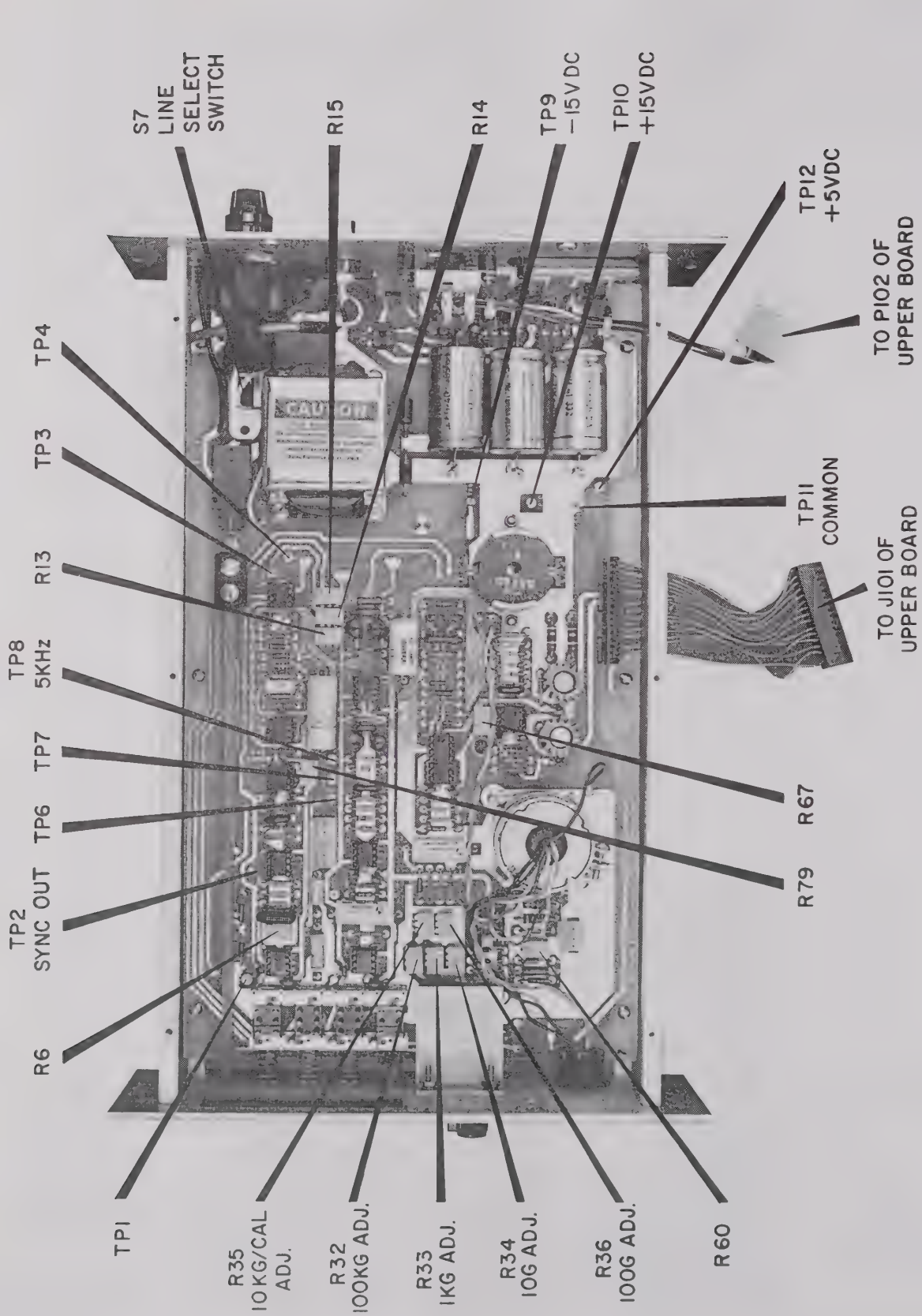


Figure 11. Components and adjustments on lower board

Chapter VII

CIRCUIT DETAILS

This description of the circuits of the Model 912 is based upon the circuit schematic diagrams shown as Figures 12 through 15. Organization of the major sections of the circuit will be clarified by reference to the block diagram, Figure 3.

STATE-VARIABLE OSCILLATOR (SVO)

The Model 912 uses a state-variable oscillator tuned to a frequency of 5 kHz which excites the Hall probe and provides a voltage reference to the sync detector. The actual SVO is formed by opamps IC9B, C, and D along with their related components. Frequency determining components are C26, C27, R50 and R52. The amplitude of the SVO is controlled by zener diode CR6 (6.2V); IC9A, and their associated components. The output of IC9D feeds a unity-gain operational amplifier, IC11, which is used as a buffer to isolate the SVO from the current generator circuit, comprised of the components associated with, and including, transistors Q1 and Q2.

HALL-PROBE

The aforementioned current generator circuit supplies 20 mA, AC at 5 kHz to the primary of transformer T2 which has a turns ratio of 1:5, resulting in a 100 mA AC current to drive the Hall probe. Potentiometer R67 (5K ohms) is used to adjust this 100 mA AC Hall current (IC). The Hall output voltage (VH) is a flux-modulated, carrier signal. VH drives the gaussmeter input amplifier IC10 through transformer T1. To cancel out any offset voltage present in the Hall element, COARSE and FINE ZERO controls (R135, R138) may be used. These controls with their associated components are used to subtract voltage from the Hall generator output while the Hall element is placed inside a zero-gauss field. See Chapter III of this manual for Hall generator theory.

Resistors R58 and R57 form a voltage divider across the output winding of T1 which scales the voltage into amplifier IC10 in the 10K and 100K ranges. The output of T1 feeds the Range switch S5C, which directs the Hall voltage (VH) to noninverting amplifier IC10; having a gain of 8.

RANGE CIRCUITRY AND GAIN STAGE

The output of IC10 is capacitively coupled through C22 to range resistors R34 through R39. These resistors are used for the calibration of the gaussmeter and represent the different gauss-ranges of the instrument. The range-select resistors can be switched to inverter IC6 by means of Range switch S5, section D.

GAIN STAGES

The output of IC6 is capacitive coupled through C14 to variable gain amplifier IC7A consisting of front-panel CAL adjustment controls R140 and 141. The output of IC7A is fed to unity-gain inverting amplifier IC7B. The outputs of IC7A and IC7B are simultaneously fed to two PMOS Analog switches contained in IC2. The gating of the analog switches is performed by comparator IC3 which is sync-ed to the 5-kHz SVO.

SYNC DETECTOR, LOWPASS FILTER

IC7, IC3, IC2 and associated components form the synchronous detector circuit. The sync output is full-wave rectified and can be observed at TP2. The polarity of the rectified voltage at the output of the detector is determined by the polarity of the measured magnetic field. Ripple out of the detector is removed by a lowpass filter consisting of R3, R4, R2, C3, C10, C9, and IC1A. This 3-pole active filter feeds a non-inverting amplifier IC1B which has a gain of 5. The output of IC1B is fed to switch S5-B which, when in the CAL position, transfers this signal to the BNC connector on the rear panel and to the A/D converter. The output of IC1B is also fed to the DC Mode switch S1, and to the operational-rectifier lowpass filter IC8, and their associated components.

PEAK DETECTOR, A/D CONVERTER

The output of IC8 feeds the Peak Detector circuit, consisting of IC4, IC5 and associated circuitry. When in PK Mode, capacitor C11 is charged to the highest voltage seen by IC5 and held there for a period with only a 0.1 percent/10 sec. decay after the peak reading is obtained. The peak charging capacitor C11 can be discharged via front-panel RESET switch S4. Outputs of Mode switches: DC (S1), AC (S2), and PK (S3) are switched to the A/D converter. The voltage going to the A/D converter from the Mode switches appears across voltage divider R101 and R139 and a lowpass filter consisting of R102 and C101. The attenuated signal is fed into input Pin 11 of the A/D converter IC107. The components associated with IC107, IC108 (10-kHz oscillator), and IC110 form the A/D converter. Potentiometer R116 is used to set the A/D converter for a full-scale reading.

DISPLAY DRIVER

The output of the A/D converter is a multiplexed 4-bit BCD code which is fed to a BCD to seven-segment Decoder/Driver (IC111). The seven-segment outputs of IC111 are fed in parallel to seven-segment LED displays DS101 through DS103. Transistor array, QZ101, consists of 7 Darlington pairs which are used for multiplex-

ing and current sinking of display data. NAND gate IC108 and associated circuitry form a 10-kHz RC oscillator which is used for the internal clock of the A/D converter.

SERIAL-TO-PARALLEL BCD OPTION

IC's 101 and 102 are dual 4-bit latches used for demultiplexing the BCD data. Flip-flop IC106A is used as a latch for demultiplexing the most significant digit. IC106B in conjunction with one-shot mV IC109 generates a data ready signal used for gating parallel BCD data into an external printer or other recording device.

POWER SUPPLY

Input power is applied to the instrument through F300, a protective slo-blo fuse, and S6, which turns power on or off. The power transformer, T3, is provided with a split primary so that operation from sources of either 115 or 230 Vac is possible. The choice is made with internal slide switch S7. When operating the instrument from a 115 Vac source, jumper J2 must be inserted.

T3 has two secondary windings. The lower secondary winding shown in Figure 12 is a center-tapped, 30-volt source used to supply both positive and negative 15-Vdc power to the circuits of the gaussmeter. The secondary voltage is rectified by full-wave bridge rectifier CRZ1, and the filtered dc is controlled by two regulators, IC13 for the positive supply, and IC12 for the negative source.

The upper secondary winding shown in Figure 14 is a center-tapped ac source used to supply the regulated 5-Vdc power circuitry. The 5-Vdc regulator is comprised of transformer T3 for dropping and isolating the line voltage, full-wave rectifier CR15, CR16, capacitive filter C37, and 5-volt regulator IC14. Diode CR22 is used to protect the regulator (IC14). Capacitor C40 is used for filtering and diode CR21 is used to protect the output from polarity reversals.

Chapter VIII

REPLACEMENT PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
Model 912 Gaussmeter Front Panel Assembly H-96310		
J200	Cable probe	HB-97424
Model 912 Gaussmeter Rear Panel Assembly H-96315		
F300	Fuse, 1/8A, 3AG, 250V, Slo-Blo, Littlefuse 313.125, or eq. (For 230V operation)	H-10710
F300	Fuse, 1/4A, 3AG, 250V, Slo-Blo, Littlefuse 313.250, or eq. (For 115V operation)	H-17166
S100	Slide-switch, DPDT, 125V, Continental-Wirt SW-326	H-9267
Model 912 Gaussmeter BCD Assembly H-96320		
IC101, 102	TTL, 4-bit latch with clear, Texas Inst. SN74116N, or eq.	H-0610-90
IC103, 107,108	Not used	----
IC104	MOS Hex inverter-buffer, Motorola MC14049CP, or eq.	H-0615-7
IC105	TTL, Quad 2-input AND gate, Texas Inst., SN7408N or eq.	H-0610-24
IC106	TTL, Dual flip-flop, Texas Inst., SN7474N, or eq.	H-0610-36
IC109	TTL, Monostable multivibrator, Texas Inst., SN74121N, or eq.	H-0610-34
Model 912 Gaussmeter Upper Circuit Board Assembly H-96301		
C101	Capacitor, ceramic 0.47 μ F, +80 -20%, 50V, Sprague 5CZ5U474D8050C5, or eq.	H-1007-939
C102, 106	Capacitor, tantalum, 10 μ F, 10%, 10V, Corning CCM-010-106-10, or eq.	H-1007-1245
C109	Not used	----

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
C104, 107, 112, 113	Capacitor, ceramic, 0.1 μ F, GMV, 50V, Kemet C320C104P5U5EA, or eq.	H-1007-1366
C105, 115	Capacitor, MPC, 1 μ F, 10%, 50V, Wesco 32MPC, or eq.	H-1007-1414
C108	Capacitor, 100pF, 2%, 500V	H-16600
C110	Capacitor, MET polyester, 0.22 μ F, 10%, 100V, Mepco/Electra C280MAH/A220K, or eq.	H-1007-1239
C111	Capacitor, 300pF, 2%, 500V, Electro Motive DM-19, or eq.	H-16622
C114	Capacitor, MPC, 0.22 μ F, 2%, 50V, Wesco 32MPC, or eq.	H-1007-1329
CR101, 102, 103	Diode, silicon, 1N914B/1N4448, or eq.	H-26482
CR104	Diode, planar, WIV125V, FD333, Fairchild, or eq.	H-31049
DS01	Opto device, display, General Instrument MAN6650-F, or eq.	H-91958
DS02	Opto device, display, General Instrument MAN6640-F, or eq.	H-91957
DS03	Opto device, display, General Instrument MAN6680-F, or eq.	H-44568
IC101, 102	(BCD option)	----
IC103	TTL/SSI Hex buffer driver, Texas Inst., SN7407N, or eq.	H-0610-45
IC104	(BCD option)	----
IC105, 106, 109	(BCD option)	----
IC107	A/D converter, 4½-digit pair, Intersil ICL71C03ACPI, or eq.	H-0625-5
IC108	MOS, Quad 2 input NAND gate, Motorola MC14011CP, or eq.	H-0615-5
IC110	Analog converter; signal conditioner, Intersil ICL8052ACPD, or eq.	H-0625-2
IC111	MOS, BCD 7-segment, decoder/driver, Motorola MC14547BCP, or eq.	H-0615-108

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
Q101	Transistor, silicon, PNP, 2N3905	H-21564
QZ101	Transistor, array ULN2004AN	H-0720-1
R101	Resistor, wirewound, precision, 40K ohms, 0.1%, 0.25W	H-1770-1384
R102- 111, 113- 115, 117- 134, 136	Resistor, metal-film, precision, value on schematic, 1%, 0.25W, Type RN¼ per RFL Spec HA-38328, or eq.	H-0410-(xxxx)
R12	Not used	-----
R116	Resistor, variable, metal-film, 1K ohms, 10%, 0.5W, ...	H-49995
R135	Resistor, variable, wirewound, 5K ohms, 5%, 10-turn, Bourns 83C1DE20J13, or eq.	H-93986
R137	Resistor, fixed, composition, 1.5 megohms, 5%, 0.25W	H-1009-799
R138	Resistor, variable, wirewound, 500 ohms, 5%, 10-turn, Bourns 83C1DE20J08, or eq.	H-96327
R139	Resistor, wirewound, precision, 10K ohms, 0.1%, 0.25W	H-1770-1341
R140	Resistor, variable, wirewound, 2K ohms, 5%, 10-turn, Bourns 83C1DE20J11, or eq.	H-96332
R141	Resistor, variable, metal-film, 2K ohms, 10%, 0.75W	H-26482
-----	Schematic diagram (Figure 12)	H-96304

Model 912 Gaussmeter Lower Circuit Board Assembly H-96305

C1,2,5-8, 12, 13, 15, 16, 19, 20, 23	Capacitor, ceramic, 0.1 μ F, GMV, 50V, Kemet C320C104P5U5EA, or eq.	H-1007-1366
C3	Capacitor, 0.00155 μ F, 2%, 500V	H-16217
C4	Capacitor, 120pF, 2%, 500V	H-16604
C9	Capacitor, polypropylene, 0.285 μ F, 2%, 100V	H-0105-82

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
C10	Capacitor, polypropelyne, 0.11 μ F, 2%, 100V	H-0105-30
C11	Capacitor, polypropelyne, 0.24 μ F, 2%, 100V	H-0105-44
C14, 22	Capacitor, metal mylar, 0.56 μ F, 20%, 200V	H-1080-242
C17, 18, 32	Capacitor, 10pF, 5%, 500V	H-16504
C21	Capacitor, MPC, 0.056 μ F, 5%, 250V, Siemens MKMB32541C.056/5/250, or eq.	H-1007-1404
C24,28- 31, 33, 34	Capacitor, ceramic, 0.1 μ F, ckt. des. cont. Kemet C320C104P5U5EA, or eq.	H-1007-1366
C25	Capacitor, MPC, 1.55 μ F, 2%, 100V, Wesco 32MPC, or eq.	H-1007-1401
C26, 27	Capacitor, 0.002 μ F, 2%, 500V	H-16222
C35, 36	Capacitor, electrolytic, 2200 μ F, -10 +50%, 40V, Stettner-Trush EG2T/40, or eq.	H-1007-1172
C37	Capacitor, electrolytic, 4700 μ F, -10 +50%, 16V, Stettner-Trush EG4T/16, or eq.	H-1007-1171
C38-40	Capacitor, tantalum, 1 μ F, 20%, 35V, Kemet T322B105M035AS, or eq.	H-1007-496
C41	Capacitor, MPC, 0.012 μ F, 2%, 200V, Wesco 32MPC, or eq.	H-1007-1119
CR1, 2	Diode, planar, WIV 125V, FD333, Fairchild, or eq.	H-31049
CR3-5, 7, 8, 11-14	Diode, silicon, 1N914B/1N4448, or eq.	H-26482
CR6	Diode, zener, 6.2V, 400 mW, 1N825, or eq.	H-29523
CR9, 10	Diode, silicon, 1N458A, or eq.	H-41978
CR15, 16	Diode, 100V, 3A, Motorola, MR501, or eq.	H-49971
CR17-22	Diode, surmetic rectifier, 1N4001, or eq.	H-38876
CRZ1	Rectifier bridge, 60V, 1A, Varo Semiconductor VM08, or eq.	H-46371
IC1	Linear JFET, dual opamp, National LF353AN, or eq.	H-0620-202
IC2	Linear analog switch, P-MOS, Texas Inst. TL604CP, or eq.	H-0620-199
IC3	Linear voltage comparator/buffer, National LM311N, or eq.	H-0620-188

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
IC4	Linear, JFET input opamp, National LF355N, or eq.	H-0620-139
IC5	Linear, opamp, National LM741CN, or eq.	H-0620-52
IC6, 10	Linear, JFET opamp, Texas Inst. TL071CP, or eq.	H-0620-161
IC7, 8	Linear, JFET dual opamp, Texas Inst. TL072CP, or eq.	H-0620-162
IC9	Linear, JFET opamp, Texas Inst. TL084CN, or eq.	H-0620-151
IC11	Linear opamp, National LM318N, or eq.	H-0620-126
IC12	Linear voltage regulator, NEG 15V, National LM320T-15, or eq.	H-0620-177
IC13	Linear voltage regulator, Fairchild 7815UC, or eq.	H-0620-74
IC14	Linear voltage regulator, POS 15V, National LM340T-5, or eq.	H-0620-178
Q1	Transistor, silicon, PNP, 2N2905A, or eq.	H-39567
Q2	Transistor, silicon, NPN, 2N2218, or eq.	H-29214
R1, 13, 79	Resistor, variable, metal-film, 25K ohms, 10%, 0.5W, Helipot 68WR25K, or eq.	H-90393
R2-11, 16-22, 25-27, 37-55, 57, 59, 61, 64-66, 68-71, 74-78	Resistor, metal-film, precision, value on schematic, 1%, 0.25W, Type RN $\frac{1}{4}$ per RFL Spec HA-38328, or eq.	H-0410-(xxxx)
R12	Resistor, fixed, composition, 510K ohms, 5%, 0.25W.	H-1009-809
R14, 32, 33	Resistor, variable, metal-film, 20K ohms, 10%, 0.5W Helipot 68WR20K, or eq.	H-44529
R15	Resistor, variable, metal-film, 50K ohms, 10%, 0.5W Helipot 68WR50K, or eq.	H-93667
R23, 24	Resistor, wirewound, precision, 20K, ohms, 0.1%, 0.25W Type 5013 per RFL Spec HA-38310, or eq.	H-1770-1402
R28	Resistor, wirewound, precision, 100K ohms, 0.1%, 0.25W	H-1770-1029

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
R29	Resistor, wirewound, precision, 200K ohms, 0.1%, 0.25W, Type 5013 per RFL Spec HA-38310, or eq.	H-1770-1432
R30	Resistor, metal-film, precision, 309K ohms, 1%, 0.125W Type RN60C per RFL Spec HA-38303, or eq.	H-1510-1599
R31	Resistor, metal-film, precision, 536K ohms, 1%, 0.25W, Type RN60D per RFL Spec HA-38304, or eq.	H-1510-1583
R34	Resistor, variable, metal-film, 200 ohms, 10%, 0.5W Helipot 68WR200, or eq.	H-96318
R35, 36	Resistor, variable, metal-film, 2K ohms, 10%, 0.5W Helipot 68WR2K, or eq.	H-90392
R56	Not used	-----
R58	Resistor, metal-film, precision, 158K ohms, 1%, 0.125W, Type RN60C per RFL Spec HA-38303, or eq.	H-1510-1723
R60	Resistor, variable, metal-film, 500 ohms, 10%, 0.5W Helipot 68WR500, or eq.	H-94296
R62, 63	Resistor, fixed, composition, 5.1 ohms, 5%, 0.5W Allen Bradley EB, or eq.	H-1009-712
R67	Resistor, variable, metal-film, 5K ohms, 10%, 0.5W Helipot 68WR5K, or eq.	H-94271
R72, 73	Resistor, fixed, composition, 24 ohms, 5%, 0.5W, Allen Bradley EB, or eq.	H-1009-713
S1-4	Switch, PB, 4-STA, 2P/STA, Centralab	H-96311
S5	Switch, rotary, 2 deck, 2 P/D, 6P	H-96309
S6	Switch, PB, power, 2P, ITT, Schadow NE15-01, or eq.	H-96321
S7	Switch, slide, 2-pos., 2-pole, Switchcraft, 275-11A1101A, or eq.	H-45534
T1	Input transformer	HB-55756
T2	Current-drive transformer	HB-55755
T3	Transformer, power, dual 115/230V, Signal Trans. DMPC-Y-15	H-96317
-----	Schematic diagram (Figure 13, 14, 15)	-----

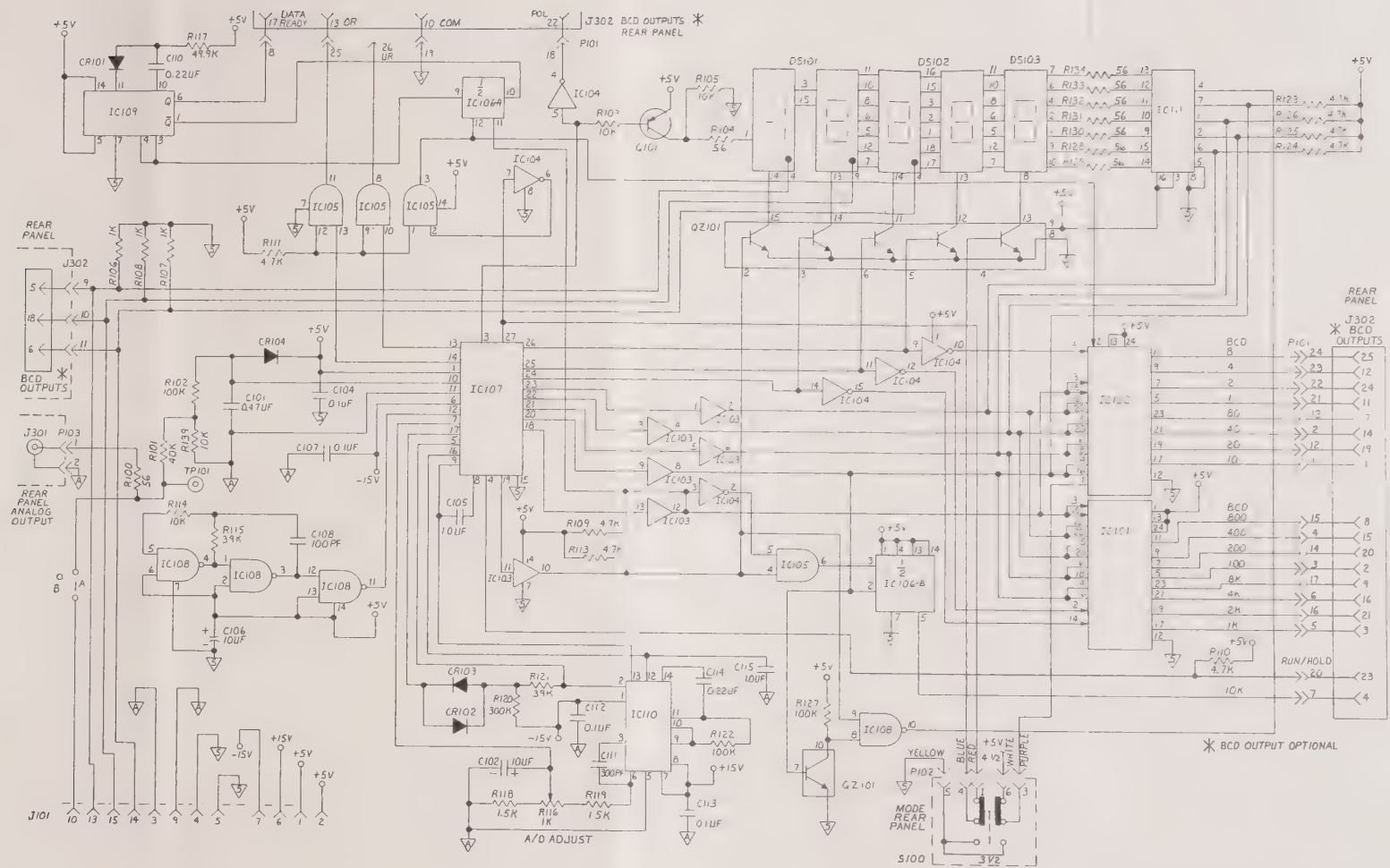
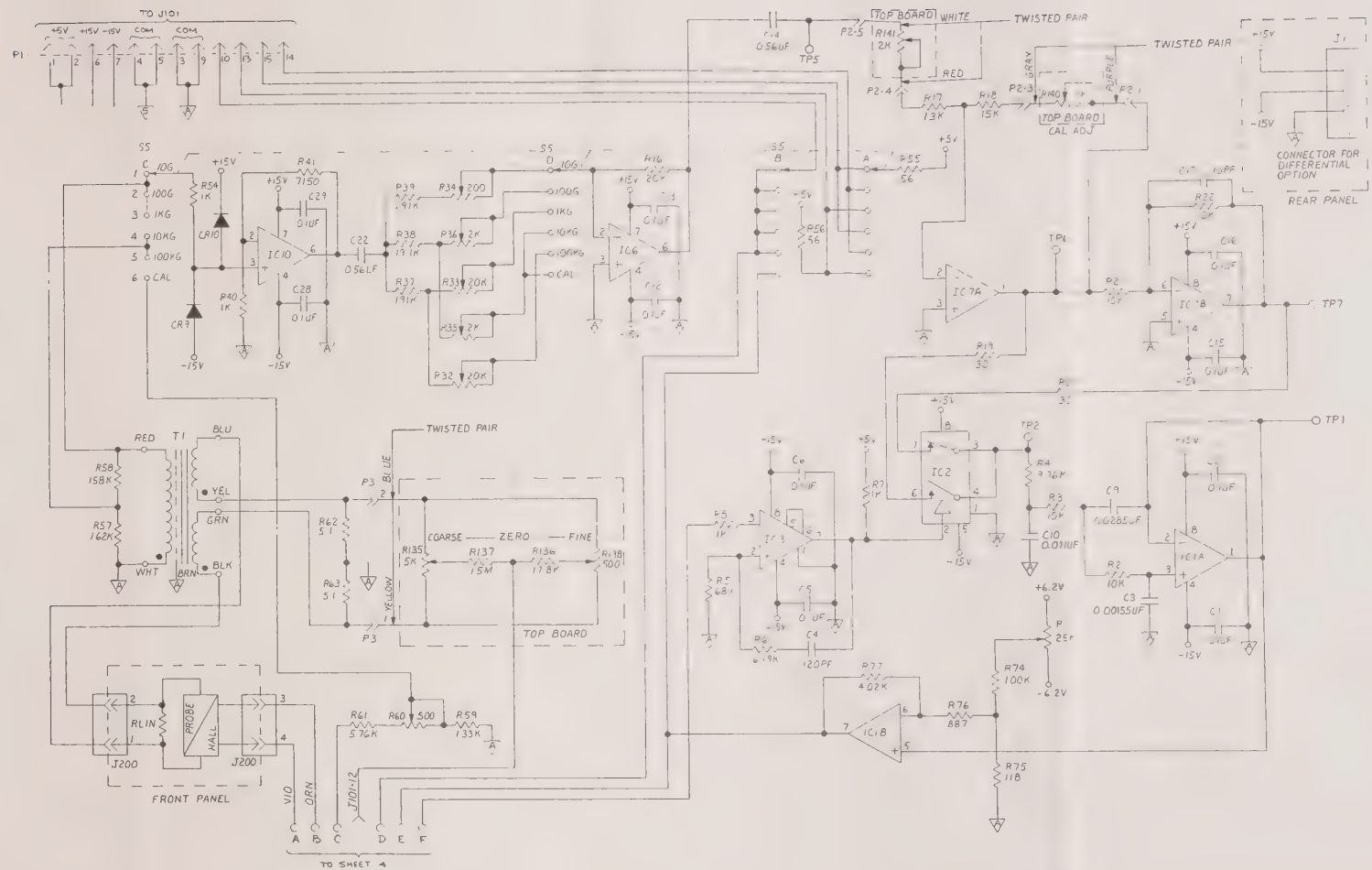


Figure 12. Schematic diagram - upper board (Sheet 1 of 4).



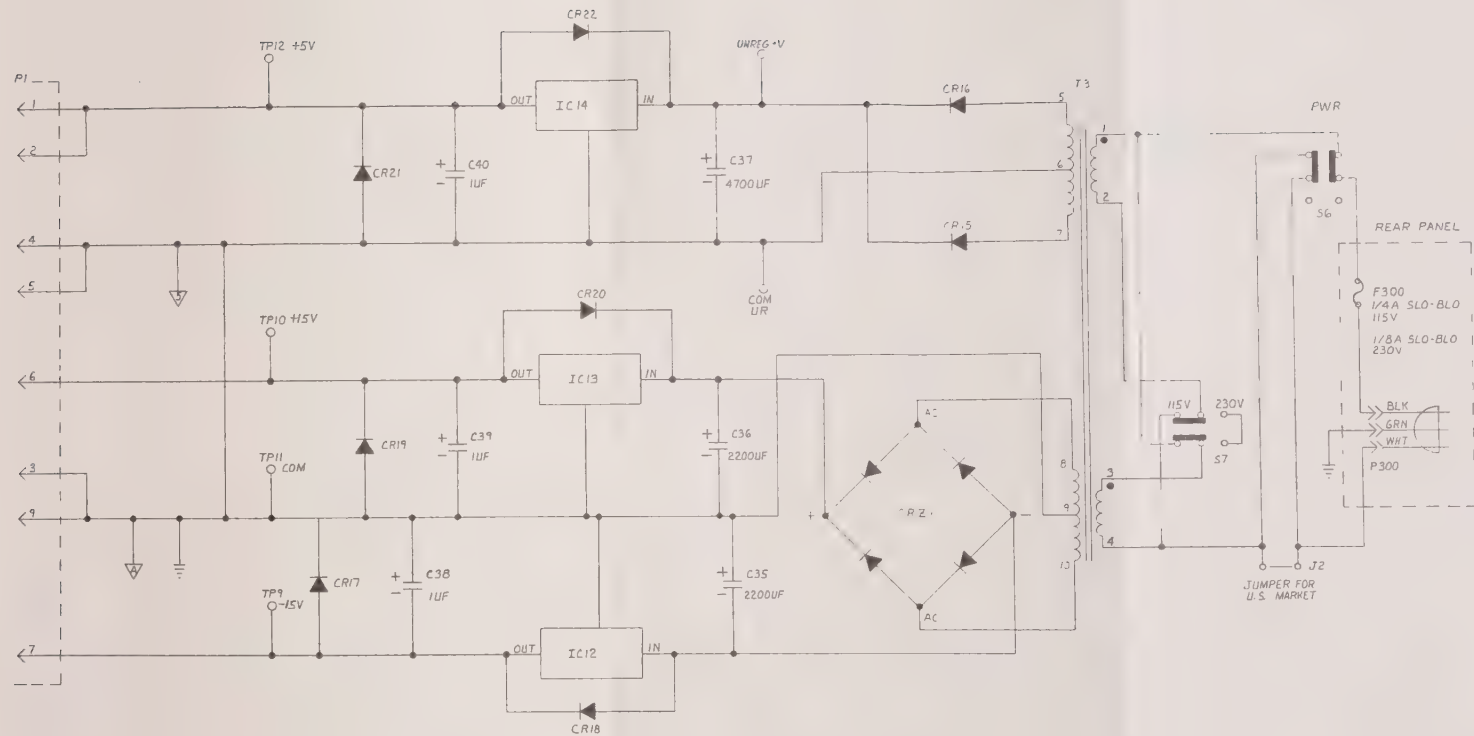


Figure 14. Schematic diagram - power supply (Sheet 3 of 4).

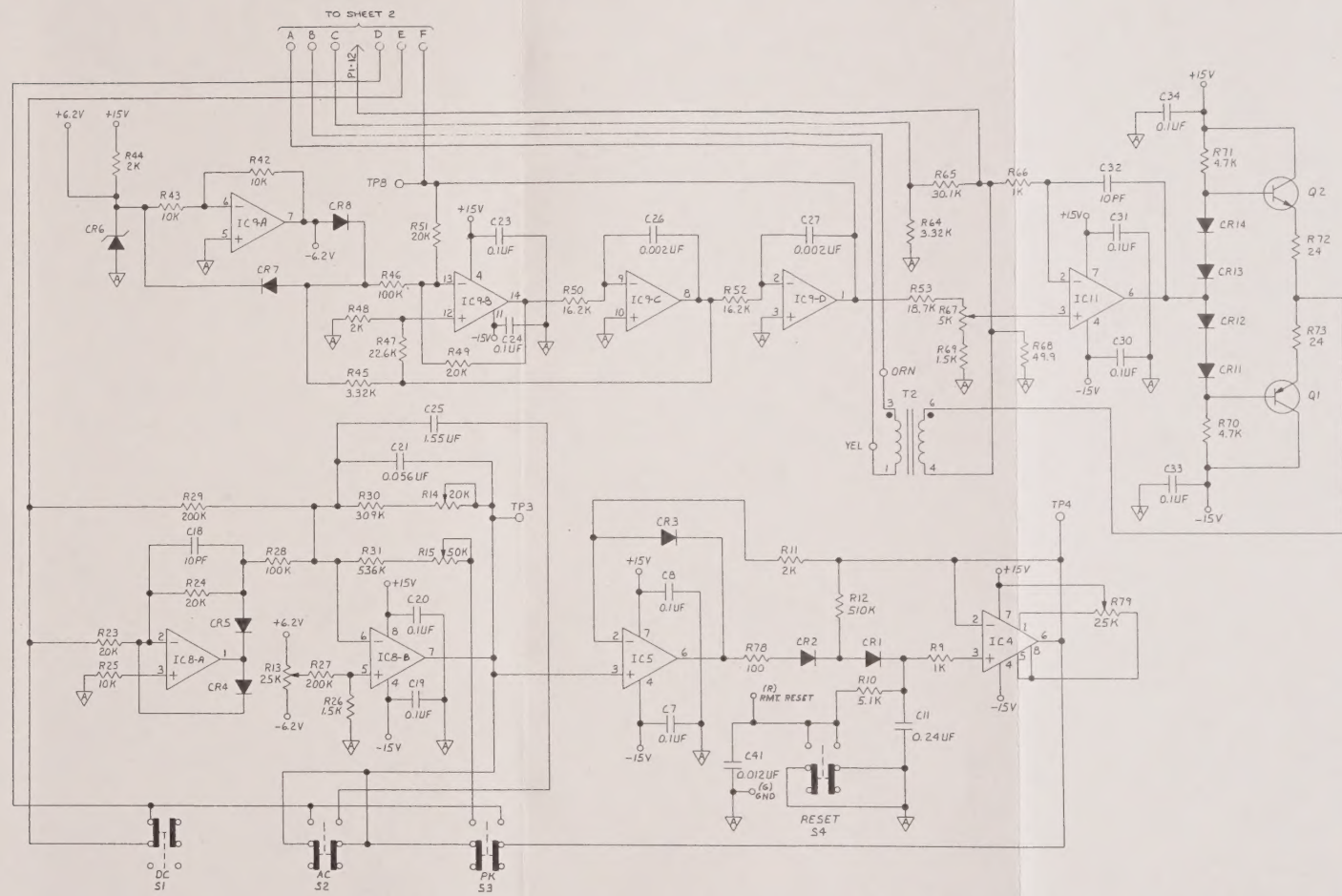


Figure 15. Schematic diagram, lower board (Sheet 4 of 4).

